What is claimed is:

1.   A catadioptric optical system comprising:

a first imaging optical system for forming an intermediate image of a first plane surface;

5   a second imaging optical system for forming a final image of said first plane surface onto a second plane surface which is substantially parallel to said first plane surface;

a catadioptric type optical system disposed in the

10   optical path from said first plane surface to said second plane surface and including a first reflecting surface which reflects light coming from through said first plane surface and a second reflecting surface for directing the light reflected by said first reflecting surface toward

15   said second plane surface, at least one of said first and second reflecting surfaces being a concave reflecting surface; and

all of the optical elements of said catadioptric optical system being disposed on a single linear optical

20   axis.

2.   A catadioptric optical system according to claim 1, wherein said first imaging optical system includes said catadioptric type optical system, and said second imaging

25   optical system includes a refraction type optical system.

3.   A catadioptric optical system according to claim

1, wherein said first imaging optical system includes

a lens group including at least one positive lens element

and said catadioptric type optical system, and said second

imaging optical system includes a refraction type optical

5   system and has an aperture diaphragm.

4.   A catadioptric optical system according to claim

1, wherein an exit pupil of said catadioptric optical

system is substantially circular.

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5.   A catadioptric optical system according to claim

1, wherein the following condition is satisfied:

$$0.04 < |fM1|/L < 0.4$$

wherein fM1 is a focal length of said concave reflecting

15   surface of said first or second reflecting surface, and

L is a distance along the optical axis from said first

surface to said second surface.

6.   A catadioptric optical system according to claim

20   1, wherein the following condition is satisfied:

$$0.6 < |\beta M1| < 20$$

wherein βM1 is a magnification of said concave

reflecting surface of said first or second reflecting

surface.

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7.   A catadioptric optical system according to claim

1, wherein the following condition is satisfied:

$$0.3 < |\beta 1| < 1.8$$

wherein $\beta 1$ is a magnification of said first imaging optical system.

5   8.   A projection exposure apparatus comprising:

an illumination optical system for illuminating a mask on which a predetermined pattern is formed; and

a catadioptric optical system according to claim 1 for projecting said predetermined pattern of said mask

10   disposed on said first surface onto a photosensitive substrate disposed on said second surface.

9.   A projection exposure apparatus comprising:

an illumination optical system for illuminating a mask

15   on which a predetermined pattern is formed; and

a catadioptric optical system according to claim 2 for projecting said predetermined pattern of said mask disposed on said first surface onto a photosensitive substrate disposed on said second surface.

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10.   A catadioptric optical system according to claim 2, wherein said first imaging optical system includes a lens group including at least one positive lens element and said catadioptric type optical system, and said second

25   imaging optical system includes a refraction type optical system and has an aperture diaphragm.

11.   A catadioptric optical system according to claim 10, wherein an exit pupil of said catadioptric optical system is substantially circular.

5   12.   A catadioptric optical system according to claim 11, wherein the following condition is satisfied:

$$0.04 < |fM1|/L < 0.4$$

wherein fM1 is a focal length of said concave reflecting surface of said first or second reflecting surface, and

10   L is a distance along the optical axis from said first surface to said second surface.

13.   A catadioptric optical system according to claim 12, wherein the following condition is satisfied:

15    $$0.6 < |\beta M1| < 20$$

wherein $\beta M1$ is a magnification of said concave reflecting surface of said first or second reflecting surface.

20   14.   A catadioptric optical system according to claim 13, wherein the following condition is satisfied:

$$0.3 < |\beta 1| < 1.8$$

wherein $\beta 1$ is a magnification of said first imaging optical system.

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15.   A projection exposure apparatus comprising: an illumination optical system for illuminating a mask

on which a predetermined pattern is formed; and

a catadioptric optical system according to claim 10 for

projecting said predetermined pattern of said mask

disposed on said first surface onto a photosensitive

5   substrate disposed on said second surface.

16.   A projection exposure apparatus comprising:

an illumination optical system for illuminating a mask

on which a predetermined pattern is formed; and

10   a catadioptric optical system according to claim 11 for

projecting said predetermined pattern of said mask

disposed on said first surface onto a photosensitive

substrate disposed on said second surface.